# SCIENCE

VOL. 94 FRIDAY, NOVEMBER 14, 1941 No. 2446

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

# THE TRANSITION FROM THE INDIVIDUAL TO THE SOCIAL LEVEL[1]

By Professor H. S. JENNINGS

THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES

THE self-sustaining biological individual in its most elementary, non-social condition is seen in the free single cell. I shall deal with such free single cells, known as Protozoa, and shall try to trace the various directions in which there is transition in their activities from the individual to the social level. I shall deal mainly with those Protozoa which are known as ciliate infusoria.

As criteria of social action several points or relations are distinguishable. First, in any grouping of organisms, are the individuals influencing each other?

Second and perhaps more important is the question of the functional value of the relations of the individuals: are there relations of mutual benefit, of cooperation in the performance of necessary biological activities? (In some cases the functional value is negative; the individuals harm each other.)

Third is the question of functional differentiation, of division of labor among individuals that are reaching socially. This is perhaps equivalent to the question whether there exists social *organization*. Only if the individuals play different functional roles is there social organization.

. Social behavior commonly manifests itself in the

[1] Symposium on "Levels of Integration in Biological and Social Systems. Group or Population Aspects," University of Chicago, Tuesday, September 23.

aggregation of individuals, or sometimes in its opposite, dispersal; in the fact that the individuals of a species tend, for whatever cause, to remain together; or that they tend to separate.

A free cell, such as the infusorian Paramecium, without companions and without aid performs the fundamental activities of life; those connected with nutrition; movements and reactions, reproduction.

One of the fundamental activities relieves it of its solitary condition. It reproduces, it divides into two. Each of the two divides, and this continues till many individuals are present.

But the world is wide; such individuals may separate, exercising no influence on each other. In many cases they do separate widely, each remaining at the individual level.

On the other hand, in some cases division of the individuals is incomplete, so that the individuals remain materially connected, forming what is called a colony. Development in this direction is to be treated by another speaker in this symposium; I shall therefore not pursue it, but deal with social relations only among individuals that separate completely, remaining free.

Such free individuals may influence each other in various ways. One of the most fundamental of these relations lies in the fact that they affect each other's reproductive processes. When two or several individuals are together, each may reproduce by division more rapidly than does the single individual alone. A functional relation has arisen, a social relation of mutual benefit.

Such phenomena were first described by Robertson in 1921. He made observations which, he believed, prove that in some species of infusoria multiplication occurs more rapidly when other individuals of the species are present. It seemed that the individuals must secrete materials which pass into the water and stimulate other individuals to reproduce. This phenomenon Robertson called the allelocatalytic reaction.

Some later investigations have failed to confirm the occurrence of such effects. Others supported the views of Robertson[2] (see the reviews of investigations in this field by Allee[3]). The great complexity of the biological environment in Protozoa makes difficult the attainment of concordant results in this field. Changing one factor in the environment changes others, so that the results of a single changed factor can be known only with great difficulty. Also it is possible or probable that different species differ in these phenomena.

But the recent critical investigations of Mast and Pace[4] and of Kidder,[5] making use of sterile cultures, yield the conclusion that in the organisms studied (Chilomonas and Tetrahymena) the so-called allelocatalytic effects are real. The organisms named are shown to modify the medium in which they live in such a way as to cause somewhat more rapid multiplication in individuals of their own kind that are present. When, however, the number of individuals in the medium becomes very great, the rate of multiplication is decreased instead of increased. How generally such phenomena occur in Protozoa is not yet known. There are strong indications that in some other infusoria similar effects are produced in a less direct way.

So far as this method of action occurs, it lends significance to the aggregations of individuals, however these aggregations are produced. When many individuals of a species are gathered together they promote each other's reproductive processes; they cause the species to increase and multiply; or in some cases they have the opposite effect.

We must therefore examine the phenomena of aggregation in our infusoria. Aggregations are produced in many ways.

One method is through common reactions to given stimuli. The free individuals produced by division of a single parent are alike, in their structure and in their physiology. Therefore they react in the same way to outer agents. In some species all swim toward a source of light. In an electric current all swim toward the cathode. All may tend to move against the force of gravity. In most species, all the individuals tend to bring their bodies into the fullest possible contact with small solid objects. These common reactions tend to keep the cells together; they produce aggregations. Protozoa of a given species may often be collected in thousands by allowing the light to fall on them from one side, or by passing an electric current through the fluid in which they swim, or by so placing them that their relation to the pull of gravity is constant. The cells then form dense aggregations. In these aggregations there is no integration save the common reaction to an outer agent. There is no differentiation of function among the individuals, no division of labor, no organization. Of mutual influence there is only the increased or decreased tendency to multiplication, resulting from the presence of many individuals together. Possibly also this coming together through a common reaction presents an opportunity for social organization to arise.

At a similar low level are aggregations which are produced as a result of the fact that the conditions for multiplication are the same for all the members of the species. Where nutritive conditions are good,

[2] T. B. Robertson, *Biochem. Jour.*, 15: 612–19, 1921.

[3] W. C. Allee, "Animal Aggregations," 431 pp., Chicago, 1931; *Biol. Reviews* (Cambridge), 9: 1–48, 1934; "The Social Life of Animals," 203 pp., New York, 1938.

[4] S. O. Mast and D. M. Pace, *Physiol. Zool.*, 11: 359–82, 1938.

[5] G. W. Kidder, *Physiol. Zool.*, 14: 209–26, 1941.

multiplication occurs, so that dense aggregations are formed. Such nutritive aggregations are exemplified by the multitudes of parasitic Protozoa found within the body of the host. In these nutritive aggregations there need be no functional differentiation of individuals, hence nothing resembling a social organization.

Returning to the aggregations resulting from motor reactions, one may observe in these a step forward, in that the individuals begin to react to each other, even to cling together. At the lowest level the individuals react to each other merely as to other physical masses. As before remarked, in many infusoria the individuals react to any small loose bodies, such as bits of filter paper, by placing themselves as fully as possible in contact with them. The infusoria are themselves small loose bodies, so that they react in this way to each other. On touching they may remain in contact, forming small dense aggregations. In these aggregations there is still no functional differentiation, no division of labor, no social organization. Though the individuals react to each other, each one plays toward the others merely the role of a small solid object.

In some of the Protozoa—particularly in the ciliate infusoria—this reaction of individuals to each other reaches a higher development, which is of a striking character. The reaction to other individuals becomes specialized, both in its object and in its character. Two individuals that happen to touch remain in contact and move together in a coordinated manner. They swim off in a coordinated motion side by side, proceeding in a graceful spiral through the water. "They may keep this up for but a few seconds, then separate, or may continue it for a much longer time, leading finally to a mating of the two. Most often, however, this caressing behavior lasts but a few moments, then the two individuals separate—possibly coming together again in a similar way a few seconds later."[6] This type of behavior has perhaps implications that are much higher than those of the behavior thus far described. It plays a role in the processes of mating, which are to be described later.

Now comes a more advanced stage of development. The individuals in many species react to each other's chemical properties, and they react in a specific way, such as keeps them together. Chemicals of certain sorts diffuse from their bodies into the water, inducing in other individuals reactions that give rise to close aggregations.

This is a great step in advance. Through it the individuals react to each other without actual contact; they react at a distance. It provides some of the most striking phenomena in the life of single-cell organisms. Many infusoria, such as various species of Paramecium, produce a secretion that is of a faintly acid reaction. This secretion diffuses from the individuals into the water, forming a zone of faintly acid solution. Other individuals coming into this acid zone swim about within it, but refuse to leave it. On coming to its boundary—to a region of marked decrease in acidity—they turn back. They perform what I called in my early work the "avoiding reaction," and this results in their remaining within the acid region. Every individual that comes into the acid region refuses to leave it, so that an aggregation is formed. And the more individuals there are present, of course the more pronounced becomes the acid reaction resulting from their secretions. The effectiveness of the material therefore becomes greater, so that the aggregation of individuals becomes continually denser and larger.

The aggregation is the result of negative reactions. The animals do not react when outside the region of acid, nor do they react when they enter it. But they do react when they arrive at a boundary at which they would leave. Here they react negatively, so as to remain. The dense aggregation thus results from negative reactions.

In Paramecium and some other infusoria the secretion which acts in this way appears to be carbon dioxide. If a bubble of carbon dioxide is introduced into water containing the organisms, they form an aggregation about it just as they do in the groups that are spontaneously formed. We know independently, of course, that the cells produce carbon dioxide in their respiratory processes. Also, chemical indicators show that the water in which the spontaneous aggregations occur has such a degree of acidity as would be induced by the presence of a small amount of dissolved carbon dioxide. The evidence is strong that carbon dioxide is the active agent in producing the spontaneous aggregations. They likewise collect in other weak acids.

In some other species of infusoria other secretions are produced, which likewise cause aggregations. The cells of these species will not aggregate in the secretions from Paramecium, nor in solutions of carbon dioxide. And Paramecia will not gather in the aggregations formed by these other species. Thus different kinds of cells have specific secretions, which induce aggregation in the species that produce them, but not in other species. For details of all these reactions, my early book (1906)[7] may be consulted.

In the production of such aggregations, then, the individuals influence each other. They are themselves

[6] H. S. Jennings, SCIENCE, 92: 539–46, 1940. Also: Leidy memorial lecture, 17 pp., The University of Pennsylvania Press, 1941.

[7] H. S. Jennings, "Behavior of the Lower Organisms," 366 pp., New York, 1906.

the agents in producing the aggregations. But nothing is known as to any functional value of these aggregations, of any reciprocal benefits to the individuals, save for the probability, already discussed, that by remaining associated in groups, they influence each other's rate of multiplication. Also, there is no differentiation of function among the individuals, no division of labor; thus no social organization.

In my youth I had certain adventures with these striking aggregations. Led by the considerations just mentioned, I plumped for the conclusion that these are not social phenomena. For this conclusion there fell upon me one of those philosophers who sum up wisdom in the maxim that "Everything is true of everything." Professor A. H. Lloyd cited my conclusion as a crass example of the failure of men of science to perceive what is under their noses. These phenomena, from his point of view *are* the social phenomena of infusoria. The analysis of the behavior into its elements and the discovery of the agents that bring it about do not alter the fact of the social nature of the behavior; they merely define the character of social behavior in these organisms.

There was perhaps justification for this criticism. These phenomena may be considered one of the lowest stages in social behavior, though hardly in social organization. And social organization actually does exist in these organisms; to this I shall come presently.

We have to this point dealt with (1) aggregations formed through common reactions to external conditions, though the organisms do not influence each other; (2) with cases in which the individuals influence each other, through the production of secretions that form solutions in the water, and that result (in some cases at least) in the formation of aggregations of many individuals. In some cases the mutual influence is of functional value, in other cases this is not known to be the case. In none of these cases is there differentiation of function among the individuals, so that there is no social organization.

A genuine social organization with differentiation of functions does however occur in the infusoria. In connection with what we may call family relations, functional differentiations appear among the individuals, and there is consequently a more or less complex social organization.

I have recently given accounts of the principal features of this organization[6,8] so that I shall here limit myself to an outline of its conspicuous features.

In the biparental reproduction of the ciliate and flagellate infusoria, two individuals partly or completely unite, and from these are descended by fission a new set of vegetative generations. In the flagellates the two individuals coalesce into a single zygote, and the zygote produces the new vegetative generations. In the ciliates the two individuals, which we shall call the parents, do not completely coalesce, but become incompletely united and while in this condition exchange halves of their genetic or hereditary materials —their chromosomes; then the two separate. Thus each individual fertilizes the other. After separation each is a new combination of chromosomes, and each now multiplies in the usual way by fission—the new generations receiving half of their chromosomes from each of the two parents (the two conjugants). It is in connection with these processes that social organization has arisen.

It turns out that the two individuals which mate are differentiated, somewhat as the two sexes are differentiated in higher organisms. In the Protozoa, however, the differentiation is physiological, not, so far as one can see, structural. In the flagellates so far as studied (in the work of Moewus[9] and others), and in some of the ciliates, there are in any species or variety just two types that mate together, as there are two sexes in higher organisms. In some other species of ciliates there are more than two of these mating or sex types. In *Paramecium bursaria,* of which I have made a special study, there are in some varieties four mating types, in another variety there are eight. Individuals that are of the same sex type do not mate together. But individuals that belong to one of the sex types may mate with individuals of any other sex type. So in the flagellates, and in those ciliates in which there are but two sex types, A and B, every pair of mates consists of one A and one B. But in the species with four sex types, A, B, C and D, pairs may consist of $A \times B$, $A \times C$, $A \times D$, $B \times C$, $B \times D$, or $C \times D$, so that six different kinds of matings are possible. In that variety in which there are eight sex types, twenty-eight different kinds of matings may and do occur.

The actual process of mating is spectacular. When stocks of two different sex types are mingled together by mixing the cultures in which they are found, there is a sudden and strong reaction. The individuals of different sex type cling together. Several individuals of one sex type may cling to one individual of the other sex type. These are joined by other individuals of both types. In this way tight groups or clots are quickly formed, many individuals of the two types

[8] H. S. Jennings, *Genetics,* 24: 202–33, 1939; *Am. Nat.,* 73: 385–89 and 414–31, 1939. Also in: Biological Symposia, Vol. 1, 1940, pp. 117–21 and 145–63. See also: "Inheritance in Protozoa," Chapter 15 in "Protozoa in Biological Research," edited by Calkins and Summers, pp. 710–71. "Genetics of *Paramecium bursaria,* II. Self-differentiation and Self-fertilization of Clones." To be published in *Proc. Amer. Philos. Soc.* "Genetics of *Paramecium bursaria,* III. Inheritance of Mating Type, in Crosses and in Clonal Self-fertilization." To be published in *Genetics.*

[9] F. Moewus, *Jahrb. f. wiss. Bot.,* 86: 753–83, 1938.

clinging together as if their bodies were covered with glue. They thus form masses of dozens or hundreds of individuals. (The formation and growth of these masses were shown in photographs projected on the screen.)

In the clotted masses the individuals adhere firmly together as if covered by some adhesive material. The clinging together is not an active or motor reaction, nor is it brought about by organs of attachment. It appears to be a physical adhesion; any part of the body of one individual thus adheres to any part of the individual of the other sex type. Often an individual visibly struggles as if trying to escape from the attachment to another individual, but in vain.

The great clotted masses remain thus with the component individuals stuck irregularly together for some hours. Then they begin to break up into smaller clots and often into chains of individuals attached end to end. This breaking up continues for two or three hours, the clots becoming smaller, until there remain only groups of two.

Thus in the course of this long and irregular adhesion the individuals of the two sex types have paired off, so that now almost all the individuals are in pairs. In every case the two individuals of any pair are members of the two different sex types. This is easily demonstrated when the individuals of the two different sex types differ in color or in other ways, as is often the case. It is further true that at any stage in the reaction, it is only members of two different sex types that adhere together; members of the same sex type show no tendency toward adherence.

The two mates remain intimately united for twenty-four to thirty-six hours, during which time they exchange halves of their chromosomes. They then separate and each begins to multiply by fission. (This description is from Jennings, 1940,[6] with verbal alterations.)

In forming these aggregations therefore the individuals of the different sex types react to each other as individuals, not merely to physical forces or to masses or chemicals present in the environment. The individuals are functionally differentiated, react selectively; and the reactions are highly functional, resulting in bisexual reproduction and the phenomena of inheritance from two parents.

In this mating behavior a part is played by the contact reactions of individuals to each other, previously described. Two individuals that come in contact react by swimming together for some distance. If they belong to different sex types (of the same variety), the contact passes into adhesion, so that the two individuals mate and complete the processes of conjugation. But if they belong to different sex types, they separate after swimming together for a time. The contact reaction appears to have the function of a trial; if the individuals in contact are appropriate mates they unite in conjugation; otherwise they do not.

The differences between the different sex types appear to be of a chemical nature. Moewus[9] has seemingly demonstrated this for the two different sex types of certain flagellates, and has determined the nature of the chemical materials characteristic for each type; they are differing carotinoids. (For a general account of sex types and their physiology, see the résumé by Sonneborn.[10]) The conditions found in the ciliates are such as to suggest similar chemical differences in this group. The phenomena indicate that the materials characteristic for each sex type do not diffuse into the water, so that actual contact of individuals is necessary for inducing the typical mating phenomena. The chemical effects are thus surface phenomena.

Besides this differentiation into sex types, the individuals of any species may be differentiated into a number of different groups or varieties. Each group or variety has its own set of sex types, but the members of different varieties never mate together, so that the varieties remain distinct. In *Paramecium aurelia,* Sonneborn[10] finds three different groups, each with two sex types, but the groups never intercross. In some cases indeed members of the different groups are physiologically antagonistic, so that contact between members of different groups results in injury or death. We have here an example of negative social reaction; relations of mutual injuriousness between certain members of the same species.

In *Paramecium bursaria* there are likewise three varieties which never intercross. Two of these varieties have each four different sex types, while the third has eight. The system of possible matings is therefore complex. There are sixteen different sex types in the species as a whole; these mate together in accordance with the rules above set forth.

The social organization in these creatures is further complicated by the conditions of youth, maturity and age, and by the phenomena of inheritance. In *Paramecium bursaria,* after mating has occurred each of the two parents (the two ex-conjugants) produces a series of vegetative generations. The entire set of individuals, of many successive generations, produced by a single parent, may be called a clone. Each clone lives for thousands of vegetative generations, throughout several years. We may distinguish in each clone a period when it is young, when it is middle-aged, when it is old. In each of these periods the clone consists of great numbers of cells, like the body of a higher

[9] Moewus, *Jahrb. f. wiss. Bot.,* 86: 753–83, 1938.

[10] T. M. Sonneborn, "Sexuality in Unicellular Organisms," Chapter 14 in "Protozoa in Biological Research," edited by Calkins and Summers, pp. 666–709, 1941.

animal, but in the infusorian the clone is formed of separate cells, scattered in different regions.

Immediately after mating has occurred the clones produced by fission of the two parents are immature. The individuals of which the clones are formed do not react sexually at all; do not mate. This period of sexual immaturity or youth lasts for many generations, extending through months or in some cases even years. During this period of immaturity it is not possible to distinguish different sex types, since there are no sexual reactions.

After a long period, some of the individuals of the young clone begin to show a slight tendency toward mating. This period of weak and scattered sexual reactions might be called adolescence. It continues for many vegetative generations, through some weeks or longer, the tendency toward sex reactions gradually increasing.

Finally the cells of the clone become fully mature. Their sexual reactions are then immediate and strong (for an account of the striking phenomena in these reactions, see Jennings[8] or Sonneborn.[10]) At this stage it is possible to distinguish the different sex types, and to examine the relations between the sex types of the parents and of the clones that descend from them; that is, to study the rules of inheritance of the sex types. We now find that all the individuals of any clone are of the same sex type and indeed that all the individuals of the two clones descended from the two parents that form a pair are of the same sex type. But different pairs of the same cross produce clones of different sex type. By crossing many individuals of two clones, one of sex type A, the other of sex type D, we obtain among the descendants clones of all the four different sex types, while certain other crosses produced only three of the four sex types (for details, see Jennings, "Genetics of *Paramecium bursaria*," III).

The condition of maturity, with its differentiation into sex types, lasts for several years—during which time each original parent has produced through fission millions of individuals, all of the same sex type, and all equally mature.

But now, as in higher organisms, all this becomes changed through the phenomena of aging. The first indication of this lies in the fact that the individuals of old clones no longer produce vigorous young when they mate. Many of the young die. A period arrives in which conjugation results in the immediate death of all the individuals that mate; or in death of all descendants after two or three fissions or less. In this later period if a young and vigorous clone is mated with the old one, this means death to all descendants of either parent.

The effects of aging become later still more pronounced. The very old clone no longer reproduces vigorously even by fission; multiplication takes place only very slowly. Many of the individuals die. The clone can be kept alive only with great difficulty. Finally, in spite of all efforts to keep it alive, all the individuals that belong to it die. The old clone has become extinct.

This account of youth, maturity, age and death is based on what occurs in *Paramecium bursaria*. In some other infusoria, notably in other species of Paramecium, the conditions appear to be very different from those just described. The period of youth or immaturity is in *Paramecium aurelia* very short, lasting but a few days (Sonneborn[10]). There is seemingly in these other species no aging. *Paramecium aurelia* and *Paramecium caudatum* may be kept alive and reproducing vigorously by fission for an indefinite period.[11] Whether mating continues to produce vigorous offspring in late age in these species seems not to have been determined.

The conditions as to aging and death in *Paramecium bursaria* agree with the earlier accounts given by Maupas[12] for a number of species of ciliate infusoria, and by Calkins[13] for *Uroleptus mobilis*. The nature and causes of the age changes are uncertain, but the facts as to decline in vigor and inability to continue biparental reproduction are clear. The change may be the result of living for long periods in unnatural conditions in the laboratory; or it may be of the same sort as senescence in higher organisms (whatever that essentially is).

Thus in the life of the infusoria the clone may be considered the unit, as the individual body is the unit in higher organisms. Both the clone and the body are composed of many cells; both show periods of youth, adolescence, maturity and age. In both, all the cells are normally of a particular sex type; and different clones, like different bodies, are of diverse sex types. The clone is like a body in which the component cells do not remain together, but are scattered in space and time.

The differentiations in the social system of the infusorian are based upon mating and reproduction. There appears to be nothing corresponding to the industrial organization so conspicuous in some of the higher organisms, such as in the ants, bees and man. The system is more comparable to what has been called "Society with a capital S," than to the division of labor in carrying on the work of the species.

To sum up, we find that a natural population of

[11] H. S. Jennings, *Bibliographia genetica*, 5: 105–330, 1929.

[12] E. Maupas, *Arch. d. Zool. Exp. et Gén.* (2), 6: 165–277, 1888.

[13] G. N. Calkins, *Jour. Exp. Zool.*, 29: 121–56, 1919; *Jour. Exp. Zool.*, 31: 287–305, 1920.

such a unicellular organism as *Paramecium bursaria* shows in connection with reproduction a considerable degree of differentiation and social organization. There are young immature clones, adolescents, sexually mature clones reproducing vigorously, and aged clones that no longer reproduce successfully, and that finally die. Among the mature clones, we may find representatives of the three different groups or varieties, and of the sixteen different sex types that constitute the three varieties. That is, the individuals are functionally differentiated, and react to each other in a highly selective way. In these respects the social system is complex, resembling that in some of the higher animals. The social organization connected with family life is of such a type as to form a natural step in the evolution of social systems, suggesting a unity throughout the world of organisms in respect to these matters.

To summarize the whole, we find that the transition from the individual to the social level begins in the one-cell organisms; and advances there by several steps. In connection with reproduction and development there has arisen a social organization of a considerable degree of complexity.

# OBITUARY

## JOHN STANLEY PLASKETT
### 1865–1941

WITH the passing of Dr. J. S. Plaskett, who died at his home in Victoria, B. C., on October 17 of this year, the astronomical world loses another of the men who were responsible for the rise of modern astronomy. Canada loses in him the leader who secured for her a prominent position in the astronomical world of to-day.

Dr. Plaskett was born on November 17, 1865, near Woodstock, Ontario. The financial resources of his family were meager, and for this reason Plaskett did not complete the work for the bachelor's degree until 1899, when he graduated from the University of Toronto. Plaskett was first an engineer in his home town of Woodstock and later for the Edison Electric Company, and for thirteen years he was an assistant in physics at Toronto. In 1903 he went as a mechanical superintendent to the Dominion Observatory in Ottawa, where he attracted the attention of Dr. W. F. King, the government astronomer of that time, and in 1905 he was appointed as director of the newly established astrophysical division of the Dominion Observatory at Ottawa. Plaskett entered upon his astronomical career at the age of forty.

During the eight years at Ottawa Plaskett's star rose rapidly. His proficiency in the adaption of the 15-inch refractor at Ottawa for spectroscopic research showed him to be one of the foremost designers of astronomical instruments. Through a careful design of the spectroscopic attachments Plaskett was able to photograph the spectra of unusually faint stars with the relatively small Ottawa refractor. The program for the measurement of stellar radial velocities which was initiated at Ottawa dealt especially with eclipsing binaries. During this same period Plaskett studied the rotation of the sun by spectroscopic means.

It was not long after his appointment at Ottawa that Plaskett began to feel keenly the need for a larger and more powerful telescope to carry on his spectroscopic researches. He discussed his needs with the chief astronomer, Dr. King, with whose strong support the project of a large reflector on Canadian soil was presented to the Canadian government. In 1913 the government placed Plaskett in charge of the development of the plans for a large reflector and soon the contracts were let for the mounting, the mirror and the optical work for a 72-inch reflector to be erected on Little Saanich Mountain near Victoria, B. C.

The mirror blank was poured at the St. Gobain works near Charleroi, Belgium, and the disk left Antwerp for the United States less than a week before the outbreak of World War I. The mounting was made by the Warner and Swasey Company of Cleveland and the optical work was performed by the Brashear Company of Pittsburgh. In the spring of 1918 the large telescope was put into operation. Because of his early training as an engineer, Plaskett was the ideal person to draw up the plans and supervise the erection of the 72-inch telescope.

Plaskett and his associates at the new Dominion Astrophysical Observatory lost no time in getting down to work. In a paper published in November, 1918, he writes:

> The mirror arrived at the Observatory on April 29, the first spectrum was obtained on May 6, and in the measurement of some 750 spectra secured since that date, these twelve spectroscopic binaries have been discovered.

Plaskett was the director of the Dominon Astrophysical Observatory from its beginning until his retirement at the age of 70 in 1935. The Publications of the Observatory published under his directorate by himself and his associates, Harper, Young, H. H. Plaskett (his son), Pearce, Redman and Beals, are a lasting monument to his driving effort and insight in astronomical matters.

The measurement and interpretation of stellar radial velocities was the main purpose of the new observatory. In the course of time Plaskett touched upon almost every phase of radial velocity work. A

great deal of useful information was gathered about the masses of the eclipsing binaries. An incidental discovery was "Plaskett's star," a massive spectroscopic binary, with two component O-type stars, having a total mass of more than 100 times that of our sun.

Largely under the influence of his son, H. H. Plaskett, the elder Plaskett became in the early nineteen-twenties very much interested in the problems of O-type stars. In a masterful paper published in 1924 Plaskett presented the results of his researches about these extremely hot stars. This paper deals with a wide variety of topics related to O stars. Their spectral characteristics were examined with great care, and much new material was given on the masses, intrinsic brightnesses and motions.

Through the studies of early-type stars Plaskett soon became very much interested in the stationary lines from ionized calcium. Originally Slipher had suggested the interstellar origin of these lines, but to most workers around 1920 it seemed more likely that they were formed in the regions directly around the star. On the basis of his observations of radial velocities and intensities of the stationary H and K lines, Plaskett decided in favor of the interstellar origin. He writes in his paper of 1924:

> The stellar and calcium velocities are generally greatly different, the former wandering all over while the latter do not differ greatly from the reflex of the solar motion. . . . A new hypothesis of widely extended, very tenuous clouds of calcium and sodium in which the star is situated and moving and which it excites and ionizes and so produces the sharp absorption line is developed.

It is hardly necessary to say that this hypothesis has been verified by subsequent studies. Plaskett became more and more interested in the interstellar gas and most of his subsequent papers contain useful information about further characteristics in the behavior of the interstellar lines.

In addition to the more glamorous type of work related to eclipsing binaries, O stars and the interstellar gas, Plaskett and his staff spent much of their time on a large routine program of the kind that forms the real backbone of modern astronomy. In cooperation with the Mount Wilson and Lick observatories, the astronomers at Victoria did their part toward completing the determination of the radial velocities for all stars in Boss' Preliminary General Catalogue of proper motions.

After the publication of a first general list, containing the radial velocities of nearly six hundred stars, Plaskett turned his attention more and more to the early-type stars. It was about this time that Oort and Lindblad advanced the theory of galactic rotation. Plaskett, who was very much impressed with this new development, saw immediately that his 72-inch reflector was the ideal instrument to provide the radial velocities of faint and distant stars that would prove or disprove the theory.

From 1928 on Plaskett's papers, published in part jointly with Pearce, deal almost exclusively with problems related to the rotation of the galaxy. The first paper in the series appeared as early as 1928, and in several numbers of the Victoria Publications the subject is considered again. It may well be said that Plaskett's measurements of radial velocities of O and B stars and of the interstellar lines in their spectra provided a firm foundation for the theory of the rotation of the galaxy. During the last five years of his directorate Plaskett gave several formal addresses, among them the George Darwin lecture for the Royal Astronomical Society on the subject of "The High-Temperature Stars" and the Halley lecture at Oxford on "The Dimensions and Structure of the Galaxy." The topic of galactic rotation was considered in almost every one of these lectures.

Shortly after his retirement Plaskett was asked by the Warner and Swasey Company to serve as a consultant for the work on the 82-inch mirror of the McDonald Observatory. He served intermittently in this capacity from 1936 to 1938, and at the symposium for the dedication of the McDonald Observatory in the spring of 1939 Plaskett presented a paper about the new telescope and mirror.

During the last fifteen years many of the highest scientific honors came Dr. Plaskett's way. He received honorary degrees from leading Canadian universities, including his alma mater, Toronto, and from the University of Pittsburgh. Between 1932 and 1935 he received the Rumford Medal of the American Academy of Arts and Sciences, the Gold Medal of the Royal Astronomical Society, the Bruce Medal of the Astronomical Society of the Pacific, the Favelle Medal of the Royal Society of Canada and the Henry Draper Medal of the National Academy of Sciences. He was a commander of the Order of the British Empire.

Plaskett was a great traveler. In the early days of the Solar Union, Plaskett was active on several of its committees; he was the Canadian representative at the meeting in Germany in 1913. In his later years he was one of the leading figures in the International Astronomical Union. He was active on many committees of the I. A. U. and president of the committee on stellar radial velocities from 1932 to 1938. After a serious illness in the spring of 1928, he came on crutches to the meeting at Leiden; Plaskett wanted to attend the meetings, where he was very eager to discuss with Oort and Lindblad his projects for the study of galactic rotation, and no doctor was going to keep him in Canada!

Plaskett's temperament was well suited to the re-

sponsibilities and duties that came naturally with the directorship of a large observatory. But whereas heavy directorial duties weigh down many a good man they seemed in the case of Plaskett to stir him to greater and more intense activity. He frankly enjoyed the job and the freedom that it gave him. I shall always remember his saying, "As a director it is your privilege to ask advice from many people, consider all suggestions carefully and then do as you please."

It is impossible to appreciate J. S. Plaskett without considering his happy family relations. Mrs. Plaskett and his son Harry played a very important part in his life. Plaskett was a strong man who could on occasion be sharp and blunt, and he needed the sweetness and kindness of Mrs. Plaskett. I doubt whether any astronomer of the present generation will ever think of him without picturing his wife somewhere in the background, not very far away. The success of Harry H. Plaskett, who after some years at Victoria went to Harvard and from there as Savilian professor of astronomy to Oxford, meant a great deal to his father. Harry Plaskett was in no small measure the cause of his father's expanding his field of research from eclipsing binaries and routine radial velocities to include spectral studies and general research on stellar motions. In knowing the elder Plaskett we can not overlook the contributions made by his wife and son.

Plaskett's name will go down in astronomical history as that of a leading designer of astronomical instruments, an untiring contributor of basic observations and a keen analyst through whose work our knowledge of the galactic system and its component stars was greatly advanced. Above all, however, we shall remember Plaskett as the man who placed Canada among the leading nations in astronomical research. We expect of the Canadian astronomers, present and future, that they carry on in the tradition established by Plaskett.

BART J. BOK

HARVARD COLLEGE OBSERVATORY

## DEATHS AND MEMORIALS

SIR ARTHUR WILLIAM HILL, since 1922 director of the Royal Botanical Gardens at Kew, was killed on November 3 when thrown from his horse while riding. He was sixty-six years old.

DR. JOHN ERIC WELIN, emeritus professor of chemistry and physics at Bethany College, Lindsborg, Kans., died on October 23. Dr. Welin was a native of Stockholm, Sweden. He was graduated from Augustana College and the University of Kansas. He served as a teacher at Bethany College beginning in the year 1891, and was elected emeritus professor in 1937.

A PLAQUE in memory of Dr. William North Rice, since 1918 professor emeritus of geology and natural history at Wesleyan University, three times acting president of the institution, was unveiled in Memorial Chapel on November 8. Dr. Rice died in 1928 at the age of eighty-four years.

AT noon on October 26, two-score friends of Dr. Robert Thomas Hill met at the foot of Round Mountain, seven miles west of Comanche, Texas, and after appropriate ceremonies, climbed the slope and scattered his ashes on the summit. It was on Round Mountain where in the eighteen seventies the orphaned printer boy, Robert Hill, first found fossil shells. His curiosity was aroused and from this place as a starting point he worked out the Comanche series now recognized wherever geology is taught. Dr. Hill died at Dallas, Texas, on July 28, 1941, aged eighty-two years.

# SCIENTIFIC EVENTS

## THE SCHOOL OF PUBLIC HEALTH OF THE UNIVERSITY OF MICHIGAN

THE Rockefeller Foundation and the W. K. Kellogg Foundation each contributed last January the sum of $500,000 to be used in the establishment of a School of Public Health at the University of Michigan. As already announced in SCIENCE, Dr. Henry F. Vaughan has been appointed dean of the school. Dr. Vaughan is a son of the late Victor C. Vaughan, who was from 1891 until his death in 1929 dean of the Medical School of the university.

According to an account of the plans of the new school in *The Michigan Alumnus*, until this year, the M.P.H. degree has been granted for thirty hours of academic work. Forty-eight hours are required for the degree now, with one year, at least, spent in the university and not less than twelve of the forty-eight hours given to field work. The practical experience is to be gained under the approval and direction of the School of Public Health, with at least six months to be devoted to it.

The program is set up so that after one year of study at Michigan the student enters the field of public health as a worker, either specializing in some branch with which he wishes to become particularly familiar or dividing his experience among several types of public health work for the purpose of gaining a general background. Not until after this practical experience is completed does the School of Public Health grant the degree.

Experience will be offered in areas outside the boundaries of the state, as well, in the South, East and West, the arrangement in the more distant areas to provide direction by expert workers in local public health units.

The advanced degree of doctor of public health will be granted to those who make contributions in special fields.

Drs. Thomas Francis, Jr., and Lowell T. Coggeshall, of the Rockefeller Foundation, New York, will be professor and chairman of the department of epidemiology and professor of epidemiology, respectively. Dr. John Sundwall, formerly professor and director of the Division of Hygiene and Public Health, has been named professor of hygiene and public health. Other transfers into the new unit include:

Nathan Sinai, professor of public health.

Dr. Emory W. Sink, assistant professor of public health.

Kenneth A. Easlick, assistant professor of public health dentistry.

Marguerite F. Hall, assistant professor of biometrics.

Lloyd R. Gates, instructor in public health engineering.

Dr. Lavinia G. MacKaye, instructor in child health.

Dr. David A. VanderSlice, instructor in school health.

## THE ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

FOUR hundred and sixty-one engineering curricula at one hundred and twenty-nine colleges and universities in the continental United States have now been accredited by the Engineers' Council for Professional Development, through the inspection program of its committee on engineering schools. Provisional accrediting has been given one hundred and four additional curricula. These figures were announced on October 30 at the ninth annual meeting of the Engineers' Council for Professional Development.

Committee reports on major activities of the council were made at the meeting, at which also officers were elected for 1941–42. R. E. Doherty, president of Carnegie Institute of Technology, Pittsburgh, Pa., was elected chairman for a second term; H. T. Woolson, executive engineer, Chrysler Corporation, was re-elected vice-chairman. H. H. Henline, national secretary of the American Institute of Electrical Engineers, was elected secretary of the council and A. B. Parsons, secretary of the American Institute of Mining and Metallurgical Engineers, New York, N. Y., assistant secretary.

Newly elected committee chairmen are: D. B. Prentice, president, Rose Polytechnic Institute, committee on engineering schools; E. S. Lee, engineer, general engineering laboratory, General Electric Company, committee on professional training; G. Ross Henninger, editor, American Institute of Electrical Engineers, committee on information. The following committee chairmen were re-elected for the coming year; R. L. Sackett, dean emeritus of engineering, Pennsylvania State College, committee on student selection and guidance; C. F. Scott, professor emeritus of electrical engineering, Yale University, committee on professional recognition; D. C. Jackson, professor emeritus of electrical engineering, Massachusetts Institute of Technology, committee on engineering ethics.

Nearly all the institutions in the United States which grant degrees in engineering have voluntarily submitted curricula for inspection by the committee on engineering schools since the beginning of the accrediting program in 1933. In 143 of 166 such institutions, 896 curricula have been inspected, including reinspection, since 1939, of 157 curricula. One or more curricula have been accredited in 129 schools. Accredited curricula number 461; provisionally accredited 104; action was deferred on 6; and accrediting has been refused to 167. Reinspections resulted in change of status for only 26 curricula. With the inspection program virtually complete, the committee is now engaged chiefly with reinspections of those curricula provisionally accredited.

## THE EIGHTEENTH EXPOSITION OF CHEMICAL INDUSTRIES

THE eighteenth Exposition of Chemical Industries will be held at the Grand Central Palace, New York, from December 1 to 6. Dr. M. C. Whitaker, of the American Cyanamid Company, is chairman of the advisory committee. Among other members of the committee are: Dr. Raymond F. Bacon; Dr. L. H. Baekeland; Dr. W. S. Landis, president of the Chemists' Club; Dr. Raymond R. Ridgway, president of the Electrochemical Society, and Dr. E. R. Weidlein, director of the Mellon Institute.

The exhibits will demonstrate the rapid advance of chemical technology, raw materials, machinery and products in the following categories: chemical products, processing materials, manufacturing ingredients, manufacturing equipment, machinery and supplies, process control, technology, containers and plant construction.

According to the official announcement, significant facts which many of the exhibits will reflect bear out the following points:

Partly chemical industries are becoming more chemical. Nonchemical industries are consuming more chemical products and adopting chemical methods. Artificial materials are rapidly replacing natural products.

Synthetics, so much in the foreground just now, are no longer regarded merely as substitutes, but as new competitive materials. Many of them are created for specific purposes and serve those purposes better than the conventional materials they replace.

From laboratories and pilot plants not merely new

products but whole new industries are coming forth. One of the characteristics of the times is the evolution and marketing of new processes and equipment in the form of complete operative units.

Three hundred exhibitors have contracted for space on three floors of the Grand Central Palace amounting to more than three acres.

The exposition is permanently organized and presented biennially as an educational institution and clearing-house of information for chemical products, chemical process and chemically controlled industries. Its purpose is to bring together at one time and place the latest products of scientific research and the inventive application of all that is new and progressive in commercial practice; thereby creating a forum for the encouragement of science and the advancement of industry.

There have been arranged conferences and consultations between leaders in science and industry, personal contacts, discussions and demonstrations of new problems to be solved and new solutions of old problems.

Admission will be by invitation and registration at the Grand Central Palace. The exposition will not be open to the public at any time. It is under the management of International Exposition Company, manager of the biennial National Exposition of Power and Mechanical Engineering, and International Heating and Ventilating Exposition, and others. Charles F. Roth is manager; E. K. Stevens associate manager.

## A BRITISH SOCIETY OF NUTRITION

*The Lancet* states that an informal group composed of about twenty representatives of the main British laboratories working on nutrition started last year to meet about once a month. But it soon became apparent that even in war-time it was desirable to have meetings that were more formal and had a much larger attendance. Representatives of the institutes interested therefore met at the Royal Institution and decided to form the Nutrition Society, with the following provisional committee: Sir John Orr, Rowett Research Institute, *chairman;* John Hammond, School of Agriculture, Cambridge, *vice-chairman;* Leslie Harris, Nutritional Laboratory, Cambridge, *honorary secretary;* A. L. Bacharach, Glaxo Ltd., *honorary treasurer;* Harriette Chick, Lister Institute; Ethel M. Cruickshank, School of Agriculture, Cambridge; H. H. Green, Veterinary Laboratory, Weybridge; Professor H. P. Himsworth, University College Hospital; Professor A. St. G. Huggett, St. Mary's Hospital; Franklin Kidd, Food Investigation Board; S. K. Kon, National Institute for Research in Dairying; B. S. Platt, Medical Research Council; H. M. Sinclair, department of biochemistry, Oxford. About 230 investigators who are or have been working on nutrition have been invited to become original members; this number includes about 50 medical men and women. During the war the society will hold meetings for the discussion of specific topics at various research institutes. The first meeting was held at Cambridge on October 18, when the subject under discussion was "The Evaluation of Nutritional Status." An introductory address was made by Sir Gowland Hopkins. This was followed by Drs. Harris, Sinclair, John Yudkin and G. W. Robertson on "Assessment of the Level of Nutrition in Man"; Dr. Platt, Dr. R. H. Dobbs and W. C. W. Nixon on "Clinical Signs of Dietary Deficiency"; Drs. C. Crowther, Green and Hammond on "Nutrition of Farm Animals." These papers were followed by an open discussion.

*The Lancet* points out that it has been difficult in the past for the clinician to keep in touch with the advances made by the biochemist, and the agriculturist planning production has rarely been in direct contact with the dietitian who knows the community's needs. This new society will bring them together in the same room.

## THE HAVANA CONFERENCE OF NATIONAL COMMITTEES ON INTELLECTUAL COOPERATION

DR. STEPHEN DUGGAN, director of the Institute of International Education, who has leave of absence for six months, has accepted the invitation of Dr. Antonio S. de Bustamente, president of the Cuban National Commission of Intellectual Cooperation, to represent the institute at the Second Conference of National Committees on Intellectual Cooperation to be held in Havana on November 15. The general purpose of the conference is to examine the basic principles on which depend the existence of intellectual cooperation and the means of assuring the survival of different cultures in an atmosphere of tolerance and liberty. Consideration will be given to such questions as the protection of intellectual property (copyright); elimination of obstacles to inter-American intellectual cooperation (high tariffs on books, customs formalities, costs of voyages); increase of cultural relationships through the cinema, radio, theater, music, art; publications and interchange of professors and students; the coordination of relations between the national committees on intellectual cooperation, and the implementation of resolutions of inter-American conferences. Dr. Duggan will present a memorandum on "The Exchange of Professors and Students."

The official delegates to the conference in Havana will represent (1) official National Committees, (2) governments of the countries that have no official

National Committees and (3) unofficial National Committees that are affiliated with the International Institute of Intellectual Cooperation in Paris. The United States delegates will be in the third category, representing the National Committee of the United States of America on International Intellectual Cooperation, which has been actively associated with the Institute of Intellectual Cooperation of the League of Nations since 1926. Since the invitations to the conference came from the Cuban National Committee and not from the Cuban government, the United States government will not be officially represented, but Dr. Charles A. Thomson, chief of the Division of Cultural Relations of the State Department, will attend as an unofficial observer.

## AWARD OF THE PENROSE MEDAL OF THE GEOLOGICAL SOCIETY OF AMERICA

PROFESSOR NORMAN LEVI BOWEN, of the University of Chicago, has been awarded the Penrose Medal by the Council of the Geological Society of America "in recognition of his achievements in the application of the principles of physical chemistry to the study of the origin of igneous rocks." The presentation will be made at the annual meeting of the society at Boston on December 30.

The late Dr. R. A. F. Penrose, Jr., established the medal named in his honor in 1927 so that the Geological Society might signalize "eminent research in pure geology and outstanding original contributions or achievements which mark a decided advance in the science of geology." The distinguished company of geologists who have preceded Professor Bowen in receiving this honor include Thomas Chrowder Chamberlin, of the University of Chicago; Jakob Johannes Sederholm, director of the Geological Survey of Finland; François Alfred Antoine Lacroix, of Paris, France; William Morris Davis, of Harvard University; Edward Oscar Ulrich, of the U. S. Geological Survey; Waldemar Lindgren, of the Massachusetts Institute of Technology; Charles Schuchert, of Yale University; Reginald Aldworth Daly, of Harvard University; Arthur Philemon Coleman, of the University of Toronto; Andrew Cowper Lawson, of the University of California; William Berryman Scott, of Princeton University, and Nelson Horatio Darton, of the U. S. Geological Survey.

The official announcement reads:

Professor Bowen, since 1937 Charles L. Hutchinson distinguished service professor of petrology at the University of Chicago, is a truly international figure in the field of petrologic research. A Canadian by birth, he took his baccalaureate degree at Queen's University, Kingston, Ontario, in 1907 and 1909. He was recalled to serve as professor of mineralogy, 1918–1920, and again in 1941 to receive an honorary degree at the centenary celebration of the university. He served as field geologist with the Ontario Department of Mines and the Geological Survey of Canada during the summers of 1907–1912. Advanced study at Massachusetts Institute of Technology brought the degree of doctor of philosophy in 1912, following which he became a member of the scientific staff of the Geophysical Laboratory of the Carnegie Institution of Washington. Here he remained, with the exception noted, until 1937 and here, with the inspiring leadership and cooperation of colleagues, he carried out his successful researches upon artificial melts simulating molten rocks which have won him high distinction including the Bigsby Medal of the Geological Society of London, and honorary membership in scientific societies of Russia, Belgium, Germany and India.

A long list of books and scientific papers published in American and European journals, testifying to productive scholarship, include contributions of significant value to the ceramic and glass-making industries. He is a co-discoverer of mullite, one of the fundamental constituents of fire clay refractories. During the world war the War Industries Board of the United States requisitioned his services in the control of production of optical glass strategically important in the successful prosecution of the war.

# SCIENTIFIC NOTES AND NEWS

A DINNER in honor of Dr. Harlow Shapley to mark the twentieth anniversary of his directorship of the Harvard College Observatory was given on November 7. More than a hundred astronomers and members of the faculty of Harvard University were present. The speakers were President Conant and Dr. A. Lawrence Lowell, president emeritus; Professor James R. Jewett, emeritus professor of Arabic; George Russell Agassiz, of the Museum of Comparative Zoology; Dr. Richard Prager, formerly of the observatory at Berlin-Babelsberg, and Professor Henry Norris Russell, of Princeton University, under whose direction Dr. Shapley worked for his doctorate. Speakers from the observatory staff were Dr. Cecilia Payne-Gaposchkin, Miss Henrietta H. Swope, Professor Bart J. Bok and Leland Cunningham.

DR. ELMER K. BOLTON, chemical director of E. I. du Pont de Nemours and Company, who was associated with the research leading to the development of nylon and synthetic rubber, received the Chemical Industry Medal for 1941 at a joint meeting on November 7 of the American Section of the Society of Chemical Industry, the New York Section of the American

Chemical Society and the New York Section of the American Institute of Chemical Engineers. Dr. Lincoln T. Work, chairman of the American section of the society, presided at the meeting. Dr. C. M. A. Stine, vice-president of the du Pont Company, spoke on the personal side of the life of the medallist, and Professor Roger Adams, of the University of Illinois, spoke on his technical achievements. The medal, which may be awarded annually for a valuable application of chemical research to industry, was presented by Dr. Wallace P. Cohoe.

DR. MARTIN H. ITTNER, since 1896 chief chemist of Colgate and Company and the Colgate-Palmolive-Peet Company, has been awarded the Perkin Medal of the Society of Chemical Industry for 1942. The award is in recognition of his work in the development of a commercial process for the hydrogenation of fatty oils. The presentation will be made on January 9 at the Chemists' Club, New York City.

THE Vermilye Medal, awarded biennially by the Franklin Institute, Philadelphia, for service in the field of industrial management, has been awarded this year to William S. Knudsen, director general of the Office of Production Management, previously president of the General Motors Corporation. The award to Mr. Knudsen is made "in recognition of long years of outstanding managerial ability in American industry, characterized by brilliant initiative, far-seeing vision and human understanding, culminating in invaluable service to his country in the administration of unprecedented production for national defense." Presentation of the award will be made on December 1 at a dinner to be given in his honor at the Franklin Institute.

THE Bigelow Medal of the Boston Surgical Society was presented on November 7 to Dr. Allen O. Whipple, Valentine Mott professor of surgery at the College of Physicians and Surgeons of Columbia University.

DR. WILLIAM LYON PHELPS, professor emeritus of Yale University and now director of the Hall of Fame of New York University, received the Gold Medal of the Holland Society of New York at the annual dinner of the society on November 13 at the Plaza Hotel.

DR. ALEXANDER RUTHVEN, president of the University of Michigan, formerly curator and director of the Museum of Zoology and director of the University Museum, was elected on November 8 at the Chicago meeting president of the National Association of State Universities.

ARTHUR F. VAN DYCK, manager of the industry service section of the RCA Laboratories, has been elected president of the Institute of Radio Engineers.

THE California Museums Conference, at its meeting in San Francisco on October 11, changed its name to the Western Museums Conference. Dr. Robert C. Miller, director of the Museum of the California Academy of Sciences and of the Steinhart Aquarium, was elected president for the current year; Dr. E. Raymond Hall, curator of mammals at the Museum of Vertebrate Zoology of the University of California, was elected vice-president, and Arthur S. Coggeshall, director of the Santa Barbara Museum of Natural History, was elected secretary-treasurer.

T. D. KRONER, assistant professor of bacteriology of the department of bacteriology and pathology of Colorado State College, has been appointed assistant professor of bacteriology at the Louisiana State University. He takes the place of Dr. C. S. McClesky, who has been called to active service in the Army.

DR. NICHOLAS E. WAGMAN has been appointed acting director of the Allegheny Observatory of the University of Pittsburgh. Dr. Edwin G. Ebbighausen and Miss Esther M. Doody have been appointed astronomers.

GRAYSON E. MEADE, a member of the staff of the Bureau of Economic Geology of the University of Texas, has been appointed instructor and research assistant in vertebrate paleontology at the Texas Technological College at Lubbock, Texas. He is a member of the staff both of the department of geology and petroleum engineering of the college and of the West Texas Museum, devoting half his time to each organization.

DR. LEONARD GREGORY PARSONS, professor of infant hygiene and the diseases of children, in the faculty of medicine at the University of Birmingham, England, who has been acting as deputy dean, has been made dean. He succeeds Dr. A. Stanley Barnes, who has resigned after serving for ten years.

DR. B. GOTTLIEB, formerly of Vienna, who spent last year at the School of Dentistry of the University of Michigan, has become associated with the Dental School of Baylor University.

DR. RAYMOND C. PARKER, formerly of the Rockefeller Institute for Medical Research, in New York City, and more recently with the Biological Laboratories of E. R. Squibb and Sons, in New Brunswick, N. J., has joined the research staff of the Connaught Laboratories of the University of Toronto.

DR. ROBERT A. MILLIKAN, chairman of the executive council of the California Institute of Technology, on November 12 presided over an Army luncheon at Los Angeles, which was sponsored by state and county military committees. Luncheon was served to five hundred civilians.

PROFESSOR RICHARD WELLINGTON, head of the division of pomology, and Dr. H. B. Tukey, chief in research in pomology, at the New York State Agricultural Experiment Station, Geneva, have been granted six months' leave of absence for travel and study. Dr. Robert S. Breed, head of the division of bacteriology, also has six months' leave to conduct a field survey for the Inter-American Committee for the Dairy Industries. Countries to be visited include Cuba, Costa Rica, Panama, Guatemala, El Salvador, Peru, Ecuador and Bolivia. A study of the research and educational facilities relative to the dairy industry will be made, together with a survey of public health activities pertaining to the control of milk supplies and other dairy products.

AN expedition to Central America from the University of California under the direction of Ruben A. Stirton, curator of mammals at the museum of paleontology, left Berkeley on November 6. It is planned to complete the collection and study of vertebrate life of El Salvador and to search for information that would establish a more correct date for the rise of the Isthmus of Panama from the sea. Mr. Stirton will be accompanied by six assistants, five of whom are teachers and graduate students in zoology, botany and paleontology in the university. They expect to stay in El Salvador for six months, during the dry season. Funds from private sources are financing the work.

THE third Barnard Hospital lecture will be given on November 18 at 8:30 P.M. in the auditorium of the St. Louis Medical Society by Dr. James B. Murphy, of the Rockefeller Institute for Medical Research. The lecture is entitled "An Analysis of the Trends in Cancer Research."

DR. BART J. BOK, of the Harvard College Observatory, will speak at a public meeting at the Franklin Institute of the Philadelphia Branch of the American Association of Scientific Workers on November 21 at 8:15 P.M. on "Pan-American Scientific Relations."

THE Committee on Scientific Research of the American Medical Association has made the following grants: Robert M. Virtue, University of Denver, formation of cholic acid; George Gomori, University of Chicago, study of enzymes in tissue sections; Frederick M. Allen, New York Medical College, reduced temperature in surgery; Robert S. Dow, University of Oregon Medical School, effects of clotting in cerebral veins; Mary Juhn, University of Maryland, applicability of feather germ reaction to tumor diagnosis; H. M. Weaver, Wayne University College of Medicine, pain on distention of the stomach; Paul Thomas Young, University of Illinois, appetites and food preferences in the rat.

THE Medical Research Council of Ireland made the following awards during the half-year ended June 30, 1941: *Training grants,* Miss D. A. Kilbride, to carry out an investigation of iodine absorption by means of balance experiments, and Miss E. O'Donovan, to assist in the investigation of the goitre problem by studying the retention of iodine under varying conditions of diet. The work in both instances will be done in the department of chemistry of University College, Cork, under the direction of Professor J. Reilly and Dr. E. M. Mason.

THE U. S. Public Health Service is planning to appoint health education consultants in various defense areas. The positions, paying $2,600 to $3,800 a year, will be filled through open competitive examinations by the Civil Service Commission. A written test will not be given, but applicants will be rated on their qualifications as shown in their applications and corroborative evidence. Appointees will work with local health officers and their staffs, advising them as to methods and procedures of health education, such as individual instruction through interviews, group instruction through discussions, talks, lectures and other educational techniques. Applicants must have completed a 4-year college course, including or supplemented by special study—or for the assistant grade, experience—in public health. In addition they must have had experience in public health education work. Further information can be obtained from the Civil Service Commission in Washington, D. C. Applications should be received not later than December 11.

THE Virginia Academy of Science presented a panel discussion on "The Value of Scientific Research to Virginia Industry," on October 17, before the twentieth annual meeting of the Virginia Manufacturers Association in Roanoke, Va. Participating in the discussion were Dr. W. C. Calcott, director of the Jackson Memorial Laboratory, E. I. du Pont de Nemours and Company; Dr. Harrison E. Howe, editor of *Industrial and Engineering Chemistry;* Dr. Arthur Bevan, state geologist of Virginia, and D. J. Cederstrom, of the U. S. Geological Survey. Mr. Cederstrom took the place of H. K. McConnell, vice-president of the Tobacco By-Products and Chemical Corporation.

A MEETING on "Science in Defense Production" was held on November 12 at the School of Mines of Columbia University, under the sponsorship of the New York Branch of the American Association of Scientific Workers. Dr. Robert W. King, assistant to the president of the Bell Telephone Laboratories, reviewed the organization of scientific men in national defense and emphasized the general aspects of the application of scientific knowledge to defense production. Follow-

ing Dr. King, Jules Korchien, national education director of the Federation of Architects, Engineers, Chemists and Technicians, discussed the mobilization of scientific personnel.

THE first Pan American Congress of Mining Engineering and Geology will be held in Santiago, Chile, during the first two weeks of January.

DR. GILBERT MURRAY, regius professor of Greek at the University of Oxford, president of the British Committee of Intellectual Cooperation, has addressed a letter to the London *Times* under date of October 1, which reads: "On reading the magnificent appeal issued to the more thoughtful part of mankind by member after member of the conference of the British Association, I wonder if I may be allowed to express the thanks of many great men, now unable to speak for themselves, who during the last twenty years have worked with me, and half the time under my chairmanship, for the acceptance of exactly the same message. Professor Einstein was able to send a communication; Sir F. Kenyon and Señor Madariaga are with us; but Bergson, Lorenz, Destree and the beloved Mme. Curie are dead, Bialobrzeski murdered, Herriot gagged, Huyzinga imprisoned; the names of others in Norway, Switzerland and other European countries it is safer not to speak. But I believe all would feel moved as I do on hearing at last the unmistakable voice of Great Britain uttering clearly that profession of faith for which we worked and appealed so long. My first impulse was almost to cry *Nunc Dimittis;* my second is to thank the British Association and its collaborators for the noble word, and to pray that in due time the deeds will follow."

# DISCUSSION

## WAR HYSTERIA IN CANADA

EARLY in September, 1940, two men rented a room in the home of Dr. Samuel Levine, research associate in geophysics at the University of Toronto, who has worked at Princeton, Pennsylvania and Cincinnati Universities in the United States and at the University of Cambridge in Great Britain and who is an authority on the forces controlling the stability of colloidal solutions. The men obtained permission to use a table in Dr. Levine's dining room for typing. Two weeks later, the police staged a midnight raid on the house and arrested the two roomers as Communists, also seizing a few pamphlets they found in the dining room. One of the arrested men, named Ehrlich, testified that these pamphlets were his property and not that of Dr. Levine. Nevertheless, the police two days later arrested Dr. Levine in his laboratory at the university for "possession of documents intended or likely to cause disaffection to His Majesty."

Dr. Levine was tried before a police magistrate and without a jury. His roomers testified that Dr. Levine knew nothing of their affairs, nor of the pamphlets. In spite of this testimony, the judge on October 10, 1940, sentenced Dr. Levine to six months' imprisonment. An appeal, heard on December 11, 1940, and again without a jury, was denied. At the appeal Professor Samuel Beatty, dean of the Faculty of Arts and head of the department of mathematics, and Professor E. F. Burton, head of the department of physics at the university, testified on Dr. Levine's behalf.

When three months of the sentence had been served, a request was made for remission of the sentence, supported by four leading professors at the university, all of whom had been Dr. Levine's teachers. These were Professor A. T. DeLury, retired dean of the Arts Faculty; Professor J. L. Synge, head of the department of applied mathematics, and Professors Beatty and Burton. President H. J. Cody, of the university, and A. W. Roebuck, Member of Parliament for the district, also supported the request, which nevertheless was denied. Dr. Levine was released from the Ontario Reformatory at Guelph on May 15, 1941. He was immediately taken into custody by mounted police and sent to an internment camp, without being permitted to communicate with his family.

A determined struggle to obtain the release of her husband was then undertaken by Mrs. Levine. Editorials and articles on behalf of Dr. Levine appeared in many Canadian papers and he received the sympathetic support of many individuals in academic and public life. The American Association of Scientific Workers began to investigate the case following a request for aid by Mrs. Levine, and entered into correspondence with the Dominion Minister of Justice. According to the latter, Dr. Levine was interned on the Minister's orders, by virtue of powers granted under the Defence of Canada Act, "to prevent him from acting in a manner prejudicial to the public safety."

In spite of all protests, nearly three months elapsed before there was held the first hearing on the internment, and another month before the character hearing, both hearings being held "in camera." Finally still another month later, Dr. Levine was unconditionally released. Additional support was received at these hearings from Professor H. Eyring, of Princeton University, and from Dr. Levine's former colleagues at Cambridge. The importance of Dr. Levine's scientific work was stressed as an added reason for his release.

Sir William Mulock, chancellor of the University of Toronto and former Chief Justice of Canada, presented at these hearings a brief summarizing his study of the original trial. He characterized the evidence as inadequate and criticized the conduct of the trial judge.

Therefore, it appears that Dr. Levine was sentenced to prison, and to have remained with his internment a prisoner for nearly a year, because the trial judge and the Minister of Justice committed acts leading to a miscarriage of justice. They were enabled to act thus because the Defense of Canada Act, adopted in war hysteria, is harsh and undemocratic. Great Britain, closer than is Canada to the war's dangers, has not found such laws necessary. For example, possession in Canada of Communist pamphlets which are freely printed in Britain is an offense, as is membership in the Communist Party. American scientists are well aware through reading *Nature* of the free and active discussions on Marxism, socialism and dialectical materialism which are engaging the interests of British scientists. It is ironical that Dr. Levine incurred the enmity of the Fascists interned in the camp so that he was in danger of physical harm, and was transferred to another camp by the authorities.

Dr. Levine's devotion to his work is exemplified by the fact that he continued as best as he could under at times brutal treatment his research work in geophysics and practically completed the mathematical treatment of a complex problem in the theory of electrical transients as applied to the exploration of subsurface formations. He is now seeking reinstatement at the University of Toronto, but this reinstatement, which rests with the Board of Governors, is not yet assured in spite of support by eminent colleagues.

The injustice to which Dr. Levine has been subjected through a year of baseless imprisonment may be continued unless the pressure of scientific opinion is exerted in his behalf. The success of the previous efforts by scientists in obtaining Dr. Levine's release augurs well for success in obtaining his reinstatement. The continuation of Dr. Levine's scientific work is particularly important now, since his geophysical researches promise to contribute significantly to the success of the Canadian war efforts in the international fight against Fascism. The scientists of the United States, as citizens of a country which is also pledged to cooperation in this fight, have the right to expect that Dr. Levine's training and abilities will be fully utilized by Canada in the aid of our joint efforts.

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## DIMINUTION IN ABILITY OF THE LIVER TO INACTIVATE ESTRONE IN VITAMIN B COMPLEX DEFICIENCY

THE recent work of Rhoads and his associates[1] on the effect of vitamin B complex in preventing cancer of the liver caused by dimethylaminoazobenzene, indicates that this involves a detoxication mechanism in which the cozymase system is implicated. This led us to investigate the possibility that the vitamin B complex might be concerned in the inactivation of other substances in the liver.

G. R. Biskind and Mark[2] demonstrated that when a pellet of a crystalline estrogen or androgen is implanted in the spleen of a castrate rat, the specific effect of the steroid is not manifest. If the spleen is subsequently transplanted subcutaneously and its pedicle ligated, the specific estrogenic or androgenic effect becomes evident. This method appeared to be ideal for investigation of the effect of vitamin B complex deficiency on the ability of the liver to inactivate steroids.

A preliminary study with estrone indicates that deficiency of the vitamin B complex in rats markedly diminishes the inactivation of this steroid in the liver. Pellets of estrone weighing approximately 5 mg were implanted in the spleens of adult castrate female rats. After a period of about 3 weeks on a normal diet, during which the rats remained anestrous, they were placed on a vitamin B complex-free diet. Within 2 weeks irregular estrual changes began to take place; after about 3 weeks the animals remained in constant or nearly constant estrus. After 39 days on the vitamin B complex-free diet the rats were sacrificed for inspection of the spleens. In no case were adhesions present that might have permitted blood from the spleen to enter the systemic circulation.

Further studies, both *in vivo* and *in vitro,* on the effect of the B vitamins on the inactivation of estrogens and androgens in the liver are in progress and will be reported in detail later.

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## PANTOTHEN

THE substance which was named pantothenic acid has now arrived at the status of an important vitamin. Since like other vitamins it is destined to be almost

[1] C. P. Rhoads, *Proc. Inst. Med. Chicago,* 13: 198, 1940.
[2] Gerson R. Biskind and Jerome Mark, *Bull. Johns Hopkins Hosp.,* 45: 212, 1939.

a household article, it seems desirable to have a shorter name for it.

The tendency to abbreviate a long word is almost irresistible. It has sometimes been convenient to use the initials p.a. to designate the substance, but these same initials are used by medical men to mean pernicious anemia, and by physiologists to designate pyruvic acid.

It is suggested that especially for popular and semi-popular use the term *pantothen* be used as a substitute or abbreviation for the longer name.

ROGER J. WILLIAMS

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## WANTED—SEDIMENTARY GALENAS

As may be seen from the abstract of A. O. Nier's work (University of Minnesota) included in the mimeographed edition of the "Report of the Committee on the Measurement of Geologic Time" just issued, especially pages 58–59, there is some indication that the age even of a common ore mineral like galena can be obtained from the proportion of isotopes in it, that the primal lead is indicated by the $Pb^{204}$ and that the younger lead has a little larger proportion of the other isotopes which may be produced by radioactive disintegration which must be going on during geologic time.[1]

It will be noticed, however, in the results given on Table 2 that the galenas of Joplin, Missouri, have a relatively high proportion of the isotopes which may be of radiogenic origin. Just how this comes to be is a matter which needs further investigation, and while there are other matters of more importance at present, it would be well to get material ready for an investigation later. Galenas from other sedimentary occurrences, not only those in the three Missouri districts but in the Mississippi, or other sedimentary formations where the occurrence and geology is well known, would be desirable. If some of these occurred in connection with barite the facts should be noted.

Rarely, however, galena also occurs in the center of balls and septaria of siderite, clay iron stone, sometimes known as nigger head, and it might be possible to get valuable results from even two grams of such material. We hope that any such material will be kept for further scientific research and the Committee on Measurement of Geologic Time will be glad to know about it.

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## COLLECTION AND FILING OF SCIENTIFIC DATA

IN SCIENCE, issue of September 19, 1941, page 278, Alfred H. Taylor of the Experimental Research Laboratories, Burroughs Wellcome and Co., U. S. A., Tuckahoe, N. Y., suggests the collection and filing of data on absorption spectra at some central depository in order to make them easily available for all research workers. He points out how widely scattered the literature on absorption spectra is and how inconvenient it sometimes proves to obtain the data wanted even if they have been known for a long time. To avoid waste of time and money he proposes what may be called a sort of clearing-house outlining at the same time a working scheme for such an institution.

It may be of interest that in another field of science, human genetics, where the difficulties encountered are very much like those mentioned by Taylor, such a clearing-house dealing with genetical data in man has been set up by the Bureau of Human Heredity, 115 Gower Street, London, W. C. I., some years ago and has met with ever-growing success. The working methods of this institution are exactly like those described by Taylor (with the only exception that there is no charge for information) and have proved so efficient that, on request of many research workers, the Bureau of Human Heredity has resolved to make use of its methods for some special tasks—*e.g.*, a survey on constitutional factors in cancer.

For this latter part of its activities the Bureau of Human Heredity has kindly been given hospitality by the Genetics Laboratory, Ohio State University, so that the work is now carried on in close cooperation by both institutions. The collection of data, although of course somewhat hampered by the conditions of war in Europe, is growing rapidly, owing to the interest of scientists all over the world; services may be expected to be available for all those interested in this field by next summer.

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# SCIENTIFIC BOOKS

## PAPERS OF WADE HAMPTON FROST

*Papers of Wade Hampton Frost, M.D.; A Contribution to Epidemiological Method.* Edited by KENNETH F. MAXCY. viii + 628 pp. Illustrated. New York: Commonwealth Fund. $3.00. 1941.

RARE is the demand for republishing articles from professional and official periodicals and bulletins, and unusual the honoring of an author by assembling after his death the significant contributions he made in medical literature to contemporary fact, method and thought. We have in hand a volume, dignified and pleasing in form, edited by men of superior discern-

[1] See also paper by Nier, Thompson and Murphey, *Physical Review*, July 15, 1941, Vol. 60, pp. 112–116.

ment with the devotion of life-long friendship and enduring admiration for the author.

To Wade Hampton Frost, student, administrator and teacher of epidemiology, we owe the flowering of this relatively new discipline of preventive medicine in the United States. The twenty papers selected for the distinction of this volume from among the sixty items of his bibliography reveal the initiation of novel inquiries, the interpretation of significantly correlated facts and the inductive and deductive reasoning by which Frost made an impression upon the science and practice of epidemiology and its public application to preventive medicine in our time.

An introduction, five sections under which the twenty papers are assembled by topics or stages of thought and objective, a bibliography and an index are included in the 628 pages of this book.

Quite apart from and in addition to the satisfaction of having in convenient form these classical studies of particular epidemics, their causes and control, the observant reader will gain from the related sections a sense of the passing of a simple descriptive epidemiology by its development into an elaborate constructive science built upon many others, and valuable as an intellectual exercise, an educational discipline and an analytical procedure of ever-expanding usefulness in determining attitudes and policies of personal and public medicine.

Frost's admiration for the demographic studies of Hirsch ("Historical and Geographic Pathology"), for the accurate observations, precise statements, the confidence, courage and logical reasoning of Snow ("On Continuous Molecular Changes," and "On the Mode of Communication of Cholera"), for Budd ("Typhoid Fever") and Panum ("On Measles") and for the studies and reports of Chapin of Providence, set goals of a perfection of presentation and deduction which he alone among American epidemiologists can be said to have achieved.

In the twenty pages of introduction by the editor, Kenneth F. Maxcy, himself a notable discoverer of new facts in epidemiology and a worthy successor to Dr. Frost as teacher, we learn of those origins and ways of life, family influences and professional experiences which had their share in affecting the directions of interest, the loyalty to scientific method and the precise ordering of evidence and its description characteristic of this man, whose thoughts and counsel drew to him a generation of eager colleagues and devoted friends.

Like many another notable commissioned officer of the U. S. Public Health Service, Frost had a varied training in hospital and field, office and laboratory, moving as orders required from one danger point to another where public need or an opportunity for evidence called him. To have shared in the first successful abatement of yellow fever in New Orleans in 1905 must have been an exhilarating experience. Coast Guard cruises off New England and to European, South Atlantic and West Indies ports, followed by assignment to the Hygienic Laboratory for several years, prepared Frost for his early studies on typhoid fever and the initiation of a life-long concern with, and constructive development of stream pollution studies in the Ohio River basin and elsewhere. Then came his studies of epidemics of poliomyelitis, of which his descriptions set a standard of thoroughness and honesty for all later authors and reports.

The pandemic of influenza of 1918 called for new methods, painstaking techniques and a broad imagination, which Frost supplied.

From 1919 until his death in 1938 Dr. Frost's life was as professor of epidemiology at the School of Hygiene and Public Health of the Johns Hopkins University, the first such department and position in this country, and in these twenty years his influence was felt wherever the mass phenomenon, the natural history of disease as it occurs among peoples related by one or more common factors, is studied, taught or practiced.

The three papers in Section One range widely from the self-evident, the obvious or almost routine to the most confusing and obscure problems of epidemic disease. It was almost a foregone conclusion that the typhoid fever and diarrheas of Williamson and the Tug River watershed in West Virginia were causally related to the pollution of water supplies by sewage. A simple situation, characteristic of the great majority of small towns and even of many of our large cities in 1910, offered an easy solution. There is an adequacy of evidence, sound reasoning, a reasonableness and comprehensiveness of conclusions and recommended measures for prevention that reveal the competence of this first report of the field epidemiologist.

In the paper on "Septic Sore Throat," in Baltimore, again a relatively common occurrence, though less often identified in 1912 than in later years, a model is given of the way to approach an acute or explosive episode of that type. The best of modern practice in controlling milk-borne streptococcus sore throats has not gone beyond the procedures advised by Frost almost thirty years ago, and every alert local health officer makes the same series of observations and uses the same reasoning now when faced with similar episodes.

In the third, a monographic paper on poliomyelitis, there are assembled the basic reports of epidemic expression of this disease in rural Iowa, 1910, in Cincinnati, Ohio, 1911, and near Buffalo, New York, in 1912. Frost as a clinical observer sets a pattern of

classification of the disease, practically useful, and generally followed to-day. No subsequent outbreaks have been recorded with more effective testimony as to direct contact transmission, as to factors of distribution and the significant items of selection of the disease. We see here that comprehensive mastery of all the evidence and the ability to keep in their relative importance each factor of probable or possible bearing on origin, spread or termination of an epidemic, so characteristic of all Frost's contributions. Taken together with Bulletin 91, which followed in 1918 and recorded the national experience with the wide-spread epidemic of 1916, this paper (Hygienic Laboratory Bulletin No. 90) remains the essence of our knowledge of the epidemiology of poliomyelitis.

Section Two includes three brief papers dealing with the systematic study of stream pollution and water purification. In the first are the basic criteria applicable to measuring and expressing the sanitary quality of water supplies. The second deals with the history of increasing pollution of surface water supplies of many of our growing cities and the effect of measures initiated by sanitary engineers to purify them. The third paper is Frost's contribution to a notable symposium reviewing a decade of field and laboratory investigations in the Ohio River valley, and fully justifying the persistent concentration of the attention of the U. S. Public Health Service upon problems of technical laboratory methods, of measuring the efficiency of filtration plants and of the natural process of purification of streams.

In Section Three we meet for the first time instances of that initiation, testing and trust of new methods and techniques in the study of the prevalence and characteristic distribution of several acute communicable diseases in their endemic expression for which Frost's later papers became notable.

The descriptive epidemiology of influenza and studies upon frequency of its attacks, case incidence and fatality and other data obtained by the canvassing method applied to characteristic samples of population, all exhibit the careful planning, thorough checking and verification and scrupulous honesty of analysis and interpretation which were inherent in any undertaking with which Frost was associated.

There follow three papers on the common cold, acute minor respiratory diseases and the reciprocal relations of these to influenza in epidemic and non-epidemic form. Each of these deals with the observation of selected groups of intelligent people over long periods (eighteen to thirty months) by reports at relatively short intervals, calling for new methods for handling a mass of quantitative material. In the fourth and fifth papers Frost deals with inspection, immunity, morbidity and carrier prevalence of diphtheria on the basis of comparable information in two well-separated periods of years in Baltimore. He seems to have settled at least for our time the three major factors accountable for the striking reduction in morbidity from diphtheria and their relative importance mathematically expressed.

Section Four gives us Frost's description of epidemiology, for philosophical and educational uses, his renaissance of Chapin's remarkable studies and methods of discovering the truth about the secondary attack rate among family or household contacts, paying loyal tribute to the genius and clarity of mind and expression of that pioneer in the practical administrative use of systematic epidemiology.

In the third and fourth papers Frost communes as it were with his associates in public health, and shares with them some of the limitations he has found inherent in the process of accounting for performance of public health services, cautioning the health officer to make no claims without ample evidence and logical reasoning, demanding of the administrator the same critical evaluation of causes and effects as is expected of the laboratory experimenter, the clinician, the statistician. His discussion of authoritative standards and a suitable method of arriving at them by a professional body has made a permanent impression upon the representative committees of the American Public Health Association and can well be taken to heart by other organizations devoted to science and the public weal.

Finally in Section Five we have three papers of the highest order, from the point of view of technical epidemiology or for their worth as permanent contributions to knowledge with prophetic implications. "Risks of Persons in Familial Contact with Pulmonary Tuberculosis," "Age Selection of Mortality from Tuberculosis in Successive Decades" and "How Much Control of Tuberculosis?" are a triad of texts indispensable to any critical analyst of the whither and how of the prevention of this disease.

A thoughtful and illuminating addendum to the bibliography of Frost's own papers is a list of twelve unpublished theses on tuberculosis by his students, now distinguished in their own right by public performance, and eight published papers on tuberculosis and rheumatic fever by the same and other collaborators.

The index is adequate, convenient and suitably brief.

This sampling of the most notable and characteristic products of the labor and thought of Wade Hampton Frost is a testament to which his successors in an indispensable science will turn for inspiration and discipline. The fortunate few who were blessed with his companionship for however short an experi-

ence will read through the lines of exquisitely expressed thoughts, and among the tables and charts of tested data, and recall the warmth, the nobility of presence, the generosity of attention and interest for others, the gentleness of his searching wit, the pervading wisdom of the man whose authorship is warrant of his distinction.

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# SPECIAL ARTICLES

## STUDIES ON INHIBITION OF FERMENTATION BY YEAST MACERATION JUICE

FERMENTATION of glucose by yeast maceration juice is dependent on the quantity of inorganic phosphate present and the state of activity of the juice. This dependence was studied by the manometric method of Warburg. The time of induction, the maximum rate of fermentation and the quantity of $CO_2$ formed served to characterize the course of the fermentation.

Addition of phosphate prolongs the time of induction and decreases the maximum rate of fermentation, and is generally followed by a diminution of $CO_2$ formation. Addition of phosphate augments the quantity of $CO_2$ formed only if the quantity of phosphate present is not sufficient to satisfy the equation of Harden. The inhibition by phosphate is different from that by fluoride, which does not prolong the induction period, although it may increase the inhibitory effect of phosphate. The inhibition by phosphate is independent of the quantity of substrate but increases with decreasing concentration of maceration juice.

A "pre-fermentation" reduces the inhibitory effect of phosphate. The inhibition is also reduced if the phosphate is added during the course of fermentation. The inhibition is least if the addition takes place during the period of maximum rate of fermentation.

The addition of acetaldehyde reduces the phosphate inhibition. A certain amount of acetaldehyde has an optimum effect. On the other hand, if fermentation is inhibited by phosphate, accumulation of acetaldehyde during the fermentation is greatly diminished.

Pyocyanine and cytochrome C + cytochromoxidase give a similar reduction of phosphate inhibition. In these cases a consumption of $O_2$ takes place, which, however, is very small in comparison with the additional formation of $CO_2$. The $O_2$-consumption is not inhibited by phosphate; on the contrary it is somewhat increased in the presence of higher phosphate concentrations.

To localize the interference by phosphate, decarboxylation of pyruvic acid and the formation of phosphoglyceric acid were examined. These processes were not inhibited by high quantities of phosphate, but were rather promoted by them. Analyses for phosphoglyceric acid revealed that its formation during the fermentation is inhibited by phosphate in the same degree as is the fermentation. After addition of acetaldehyde, however, its formation sets in nearly immediately and is not depressed following addition of phosphate.

The phosphate inhibition evidently affects one or more of the slower links following the formation of phosphoglyceric acid, rendering them still slower. In this way it inhibits the formation of acetaldehyde necessary to oxidize glyceric aldehyde phosphoric acid. Both the fact that phosphate renders the oxidation of glyceric aldehyde phosphoric acid more complete and the greater deficiency of acetaldehyde in the presence of more phosphate seem to be responsible for the greater $O_2$ consumption in the presence of pyocyanine or the cytochrome system.

The different degrees of inhibition obtained in the various periods of fermentation or after a "pre-fermentation," can be explained by varying formation and accumulation of acetaldehyde and by the different speeds of the inhibitable links.

The inactivation of the maceration juice, which depends on age, temperature and dilution, decreases fermentation in the same manner as the addition of phosphate. The rate of the inactivation is greater, the lower the concentration of the juice. It is not based upon a monomolecular reaction. During the first stages of inactivation (which may be rather prolonged at low temperatures or scarcely demonstrable in the neighborhood of 40° C.) the activity remains constant. In later stages the inactivation is accompanied by turbidity formation. During the inactivation an augmentation of susceptibility to phosphate inhibition takes place, whereas the inhibition by fluoride or monoiodacetic acid is not similarly augmented.

In the presence of phosphate the inactivation and the formation of turbidity are retarded. It may be supposed that the original phosphate content of the juice acts as a stabilizer against inactivation.

The addition of acetaldehyde reduces the effects of the inactivation as well as does a short "pre-fermentation." This indicates that the enzyme is able to reactivate itself to a certain degree by the fermentation process.

A detailed exposition of this investigation will be published in *Arkiv för kemi,* Stockholm.

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## ON THE PORPHYRIN NATURE OF THE FLUORESCENT "BLOOD CAKED" WHISKERS OF PANTOTHENIC ACID DEFICIENT RATS

WEANLING rats fed a diet deficient in pantothenic acid develop, in a period of four to six weeks, peculiar symptoms characterized by the accumulation of red material around the nose and on the whiskers. Because of the superficial resemblance of this red material to coagulated blood the condition has been described as "nose bleed"[1] or "blood caked" whiskers.[2] However, no thorough studies on the chemical nature of the deposited red material have come to our attention. We have investigated the nature of the red material from a chemical point of view and have endeavored to trace its origin in the pantothenic acid deficient rat.

The red deposits on the nose and whiskers of pantothenic acid deficient rats exhibited a bright red fluorescence in ultraviolet light. An ultraviolet lamp (G.E.B.H.$_4$) was used as a light source. Hemochromogen tests showed that only a minute quantity of the material is hemoglobin. A large proportion was found to be a coproporphyrin. The heavy red deposit around the mouth and on the whiskers of several pantothenic acid deficient rats was collected by washing with water slightly acidified with acetic acid. Zeile and Rau's[3] modification of H. Fischer's extraction method for porphyrins was followed. The completeness of the extraction was controlled with the aid of ultraviolet light. The red fluorescent material was completely driven into 0.54 per cent. HCl (coproporphyrin fraction) and showed after washing with chloroform the following spectrum in 25 per cent. HCl: I 551 mμ II 570 mμ III 594 mμ; the spectrum of its copper salt in pyridine was : I 565 mμ II 528 mμ. These spectra were compared with those of a sample of synthetic coproporphyrin I[4] and its copper salt respectively and proved to be identical under the experimental conditions. The spectroscopic measurements were carried out with the aid of a Zeiss pocket spectroscope, equipped with a wave-length scale.

Since it has been shown that the Harderian glands in rats exhibit a red fluorescence, and contain and secrete porphyrin[5,6] it was assumed that the fluorescent material might pass to the nose and whiskers of the rats by way of the naso-lacrimal duct. An attempt to test this hypothesis revealed a fluorescent naso-lacrimal duct in a pantothenic acid deficient animal. It therefore appeared likely that the source of the porphyrin deposit was the Harderian gland. The Harderian glands were removed from eleven weanling albino rats; to insure complete removal of fluorescent tissue the operation was performed under ultraviolet light. The animals were then placed in all-glass cages and fed a diet deficient in pantothenic acid. Seven unoperated controls subsisting on an identical diet all developed fluorescent porphyrin deposits on the nose within six weeks. The eleven operated animals developed the other known symptoms of pantothenic acid deficiency, but no fluorescent red-colored material appeared on the nose, whiskers or fur.

Three grams of the fresh Harderian glands (from 17 animals) were extracted for porphyrins. In agreement with Derrien and Turchini[5] the main fraction appeared to be protoporphyrin. However, a very small fraction could be extracted with 0.54 per cent. HCl, and this was identified spectroscopically as coproporphyrin. The spectrum in 25 per cent. HCl was : I 553 mμ II 595 mμ; the spectrum of the copper salt in pyridine was I 565 mμ II 530 mμ under the conditions of our experiments.

We therefore conclude that the red deposit around the nose and on the whiskers of pantothenic acid deficient rats is not blood but coproporphyrin and that this is derived from the Harderian gland.

After this paper was submitted for publication it was noted that Chick, Macrae and Worden[7] had attempted to characterize the reddish exudate which accumulates on rats deprived of vitamin $B_2$ factors. Our own independent and more exhaustive investigations confirm their observation that the material is not blood, and that it contains large amounts of porphyrin. They state that the material contains protoporphyrin. The data submitted above identify the porphyrin washed from the whiskers and fur of our rats as coproporphyrin.

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[1] F. S. Daft and W. H. Sebrell, *Pub. Health Rep., U. S. P. H. S.*, 54: 2247, 1939.

[2] K. Unna, *Jour. Nutrition*, 20: 565, 1940.

[3] K. Zeile and B. Rau, *Zeits. physiol. Chem.*, 250: 197, 1937.

[4] The authors wish to thank Mr. Curt C. Porter, Department of Physiological Chemistry, The Johns Hopkins School of Medicine, for his generosity in supplying one of them with a highly purified sample of synthetic coproporphyrin I.

[5] E. Derrien and J. Turchini, *Compt. rend. Soc. biol.*, 91: 637, 1924.

[6] A. L. Grafflin, *Anat. Rec.*, 79: 25, 1941.

[7] H. Chick, T. F. Macrea and A. N. Worden, *Biochem. Jour.*, 34: 580, 1940.

[8] Rockefeller fellow, on leave of absence from the University of Maryland Medical School.

[9] The expenses of this study were defrayed in part by the Research Fund of the Yale University School of Medicine.

## THE POLAROGRAPHIC CURVE OF SERUM FROM RATS FED p-DIMETHYL-AMINOAZOBENZENE[1]

WHITE and White[2, 3] have demonstrated that growth inhibition resulted in young rats when carcinogenic chemicals and certain other organic compounds were included in the diet, and they reported that this could be corrected by dietary supplements of l-cystine and dl-methionine. It was concluded that certain carcinogens, as well as non-carcinogens, could induce a specific deficiency of the sulfur containing amino acids probably by imposing on the organisms an increased requirement for organic sulfur in the form of cystine or methionine for detoxication mechanisms. Since Brdička[4] has shown that the production of the polarographic curve obtained with blood serum is quantitatively proportional to the concentration of the sulfur-containing amino acids, we used the polarograph to obtain information regarding the level of these substances in the blood of rats on diets containing p-dimethylaminoazobenzene (butter yellow). Rusch, Klatt, Dirksen and Meloche[5] have pointed out that cystine is highest in the albumin fraction of the blood and found that the height of the polarographic curve was directly proportional to the amount of serum albumin.

Twenty-four young albino rats weighing 60–70 gm were divided into two series of 12 each. Three different basic diets were used. Diet I was composed of dextrin 77, casein 6, butter 5, crisco 5, salts 4, brewers yeast 2 and cod liver oil 1. Diet II was the same except that dextrin was reduced to 67, the casein was raised to 16, and 0.02 per cent. butter yellow was added. Diet III was the same as diet I except that 0.067 per cent. cystine and 0.02 per cent. butter yellow were added. In series I, three rats were killed at the beginning of the experiment, the remainder put on diet I and kept for 21 days when 3 more were sacrificed. Butter yellow (0.02 per cent.) was added to diet 1 and after 9 days on this ration, 3 were killed and the remaining 3 placed on diet II for 7 days more after which time they were also sacrificed. Series II was performed in the same manner, except that the rats were kept on diet I for 30 days before making any changes and diet III was used instead of diet II. Blood for the polarographic determinations was obtained when the rats were decapitated and it was prepared by the method previously described.[5]

[1] This study was supported by the Jonathan Bowman Fund for Cancer Research.

[2] J. White and A. White, *Jour. Biol. Chem.*, 131: 149, 1939.

[3] J. White, *Jour. National Cancer Inst.*, 1: 337, 1940.

[4] R. Brdička, *Nature*, 142: 617, 1938.

[5] H. P. Rusch, T. Klatt, V. W. Meloche and A. J. Dirksen, *Proc. Soc. Exper. Biol. and Med.*, 44: 362, 1940.

The average height of the polarographic curves of the rats on normal diets in series I was 19.7 mm, but decreased to 17.5 mm on diet I, was further lowered to 15.8 mm when butter yellow was added and increased to 17.8 after the level of casein was raised. In series II, the figures were 20 mm for the controls, 15.3 mm after 30 days on diet I, 13.3 mm after butter yellow was added and 14.8 mm when additional cystine was included in the diet. In Fig. 1 representative

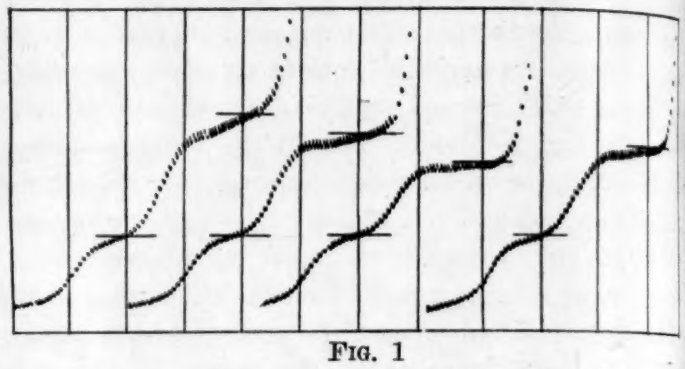

FIG. 1

curves of each group are arranged in the order just given. The lower curves found in series II were probably due to the greater depletion of cystine, since the rats were kept on the deficient diet over a longer period. The failure of the curves to return to the normal starting height may have been due to inadequate amounts of essential factors or to the short period allowed for recovery. From these results it is probable that the addition of butter yellow to the diet of rats resulted in a reduction in the level of the sulfur containing amino acids of the blood sera. This is in harmony with results obtained by different methods as reported by White and White.

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## VITAMIN $B_6$ AND GROWTH OF EXCISED TOMATO ROOTS IN AGAR CULTURE[1]

ROBBINS and Schmidt[2] reported that pyridoxine (vitamin $B_6$) had a marked favorable effect on the growth of excised tomato roots in a mineral-sugar solution containing thiamin. Bonner and Devirian[3] obtained similar results. Bonner[4] reported beneficial results with five strains of tomato. Robbins[5] observed that the excised roots of one inbred tomato showed little response to pyridoxine while those of another

[1] Contributions from the Department of Botany, Smith College, New Series, No. 7.

[2] W. J. Robbins and M. B. Schmidt, *Am. Jour. Bot.*, 26: 149–159, 1939.

[3] J. Bonner and P. S. Devirian, *Am. Jour. Bot.*, 26: 661–665, 1939.

[4] J. Bonner, *Am. Jour. Bot.*, 27: 692–701, 1940.

[5] W. J. Robbins, SCIENCE, 92: 416, 1940.

inbred and the $F_1$ heterotic hybrid exhibited considerable response. White[6] concluded that this vitamin did not improve the growth of excised tomato roots, while glycine had a marked beneficial effect.

In the experiments referred to above a liquid culture medium was used. The writer has determined the effect of pyridoxine on excised tomato roots in agar culture in experiments carried on at the New York Botanical Garden. The nutrient medium consisted of a modified Pfeffer's solution containing 1.0 per cent. sucrose and 0.5 per cent. purified agar to which thiamin, pyridoxine, nicotinamide, neopeptone, glutamic acid and glycine were added in various combinations.

The strain of excised tomato roots was that originally isolated by Robbins and Schmidt.[7] Fragments of roots which had grown for 47 or more successive passages in a mineral-sugar solution containing thiamin or a mineral-sugar solution containing the thiazole intermediate of thiamin were used as inoculum. The inoculum was therefore in all probability free of any material other than that synthesized by the roots or contained in the solutions given. Uniform pieces of the roots growing in these liquid cultures were transferred to the agar medium in Petri dishes. These were incubated in a moist chamber at 25° C. in the dark. In subsequent passages at eight- to ten-day intervals strongly growing and uniform appearing root tips 1.0 cm in length were transferred from the medium in one Petri dish to the same medium in another. Growth was determined at the end of each passage by measuring the increase in length of the main root. Growth of branch roots was not included in these measurements. In each experiment from 12 to 31 root tips were grown on a particular medium.

In the basal medium the roots seldom grew for more than two passages. With the addition of thiamin similar root tips grew about 2.0 mm daily. In the same experiments, where pyridoxine was added to the agar medium containing thiamin, similar root tips generally showed a daily increment of 5.0–6.0 mm, or in several passages as much as 8.0 mm. Supplementing this medium with nicotinamide had no appreciable effect on the rate of growth. The further addition of neopeptone decreased the rate of growth to two thirds of that in the medium containing thiamin and pyridoxine. The addition of glutamic acid to the agar medium containing thiamin decreased the rate of growth. The addition of glycine to the agar medium containing thiamin had little or no effect.

Although the growth of the roots in the agar medium was less rapid than in the same medium without the agar, they appeared healthy and vigorous where suitable growth-substances were present. In one experiment the roots in the agar medium containing both thiamin and pyridoxine have grown for more than twenty passages during more than two hundred days with no diminution in rate of growth. The roots in the agar medium containing both thiamin and pyridoxine showed the characteristic hooks and curls noted by Robbins and Schmidt.[2]

Pyridoxine was of distinct benefit to the excised tomato roots in these experiments. Neither glutamic acid nor glycine in the amounts used appeared able to replace it.

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[6] P. R. White, *Am. Jour. Bot.*, 27: 811–821, 1940.
[7] W. J. Robbins and M. B. Schmidt, *Bot. Gaz.*, 99: 671–728, 1938.

# SCIENTIFIC APPARATUS AND LABORATORY METHODS

## THE PREPARATION OF STERILE PROTEINS IN THE "LYOPHILED" STATE[1]

IN the preparation of certain proteins (fibrinogen, thrombin) and proteinaceous material (chick embryo extract) in the lyophiled state, for uniform tissue culture media, it was noted that it was possible to obtain sterile preparations without the application of the elaborate and costly precautions necessary for aseptic technique. The sterility of these preparations was at first attributed to an empirical treatment of the dry protein with sodium-dried toluene for ten minutes at 60° C. The subsequent discovery that the method of removal of toluene after this treatment left traces of the toluene still in the material made it seem possible that it was the action of the compound over a period of some days that was effective. This was confirmed by the observation that mass cultures of bacteria in the lyophiled state were killed by the application of dry toluene for a period of four weeks, but not by treatment with toluene for ten minutes at 60° C.

The role of the lyophile process itself in the sterilizing action was not at first suspected, since this is a common method of preserving bacterial cultures.[2]

The publication of Heller's[3] study of factors involved in survival and death of bacteria in the desiccated state made it clear that lyophiling itself reduced considerably the number of organisms in a bacterial culture.

Because of the practical importance of being able to prepare, relatively easily, large quantities of sterile

[1] Aided by grants from the Rockefeller Foundation and from the Research Board of the University of California.
[2] H. F. Swift, *Jour. Exp. Med.*, 33: 69, 1921.
[3] George Heller, *Jour. Bact.*, 41: 109, 1941.

lyophiled protein for tissue culture studies, we made quantitative investigations of bacterial survival after certain combinations of chemical treatment and lyophiling.

The test medium chosen was Brewers thioglycollate broth[4] because it supports the growth of anaerobes as well as aerobes.

A local contaminant (gram positive spore-former) was used as a test organism, since previously it had been shown to be more resistant to chemical and thermal treatment (toluene, ether, chloroform, acetone, propylene glycol, various degrees of heat) than any of four standard test organisms,[5] *Staph. aureus, Staph. albus, Ps. pyocyanea, B. subtilis.* The organism was always used as a 24-hour culture of a 24-hour culture.

The results of these experiments are summarized in Tables I and II.

TABLE 1

STERILIZING EFFECT OF CHEMICAL ADDED TO THE DRY RESIDUE AFTER LYOPHILING. NUMBERS EQUAL VIABLE ORGANISMS/ML.

| | Incubation 20 hours 37° C. | Lyophiled 24 hours | Lyophiled 24 hours plus Toluene | Relyophiled |
|---|---|---|---|---|
| Experiment 1 | 2,900,000 | 100,000 | | |
| Experiment 2 | 2,800,000 | | 130,000 | 30 |

TABLE 2

STERILIZING EFFECT OF CHEMICALS ADDED TO THE AQUEOUS MEDIUM BEFORE LYOPHILING

| | Incubation 20 hours 37° C. | Lyophiled 24 hours |
|---|---|---|
| Inoculated medium .... | 1,100,000 | 53,000 |
| Inoculated medium plus toluene ..... | Less than 2,000 | 0 |
| Inoculated medium plus propylene glycol .... | Less than 2,000 | 0 |

These results indicate that reasonably clean handling of the proteinaceous material, plus toluene treatment and lyophiling, will result in a sterile product.

The material from which proteins intended for subsequent sterile use are to be prepared should be handled in a clean way to reduce sources of contamination. Sufficient toluene should be added to saturate the original material, which then should be worked up in a cool room as quickly as possible to avoid multiplication of the contaminants present. If the product is not sterile, after lyophiling, it may be dissolved in the amount of distilled water removed, toluene again added and relyophiled. In a planned experiment, using organisms in prime condition and using a selective medium, the organisms became non-culturable.

Preparations of fibrinogen, thrombin and plasma, all from slaughter-house beef blood, and of chick embryo extract handled in the open air in non-sterile containers, have been obtained in the lyophiled state in sterile condition in this manner.

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[4] J. H. Brewer, *Jour. Bact.*, 30: 10, 1940.

[5] M. S. Marshall, J. B. Gunnison, M. P. Luxen, *Proc. Soc. Exp. Biol. Med.*, 43: 672, 1940.

## REMOVING FROZEN PLUNGERS OF GLASS SYRINGES

THE method of removing the plungers of frozen glass syringes suggested by McCoord[1] was formerly used in our laboratory exactly as he describes it. However, the difficulty in some cases due to the leakage of the water around the rubber gasket caused me to devise a somewhat surer method.

The same principle is used as that suggested by McCoord in which a small tuberculin syringe is utilized to give the necessary hydraulic pressure. Instead of connecting the two syringes by a hypodermic needle and rubber gasket, we have made use of a connector fashioned from the hubs of two broken hypodermic needles. These are brazed together so that they can be used to join the two syringes. In order to make certain that the hole in the needles has not been plugged up in the process of brazing they are subsequently drilled out with a small metal drill. It is important that all air be removed from the system before exerting pressure. This can be accomplished in the "frozen" syringe by using a fine neeedle which will pass freely through the nipple.

This method has been used in our laboratory for the past five years and has never failed to release the plungers even though they are sealed by coagulated blood.

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[1] SCIENCE, Vol. 94, p. 170.

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